Pulse Modulation

Pulse Modulation is a technique in which the signal is transmitted with the information by pulses. This is divided into Analog Pulse Modulation and Digital Pulse Modulation. (**Pulse modulation** is a type of modulation in which the signal is transmitted in the form of pulses. It can be used to transmit analogue information).

In analog pulse modulation, a periodic pulse train is used as the carrier wave, and some characteristics features of each pulse (e.g. Amplitude, Position, and Width) is varied in a continuous manner in accordance with the corresponding sample value of the message signal. Thus in analog pulse modulation, information is transmitted basically in analog form, but the transmission takes place at discrete times.

Pulse modulation can be classified into two major types

1- Pulse Analog Modulation

a) Pulse Amplitude Modulation (PAM)

b) Pulse Time Modulation (PTM)

i. Pulse Width Modulation (PWM)

ii. Pulse Position Modulation (PPM)

2- Pulse Digital Modulation

a) Pulse Code Modulation (PCM)

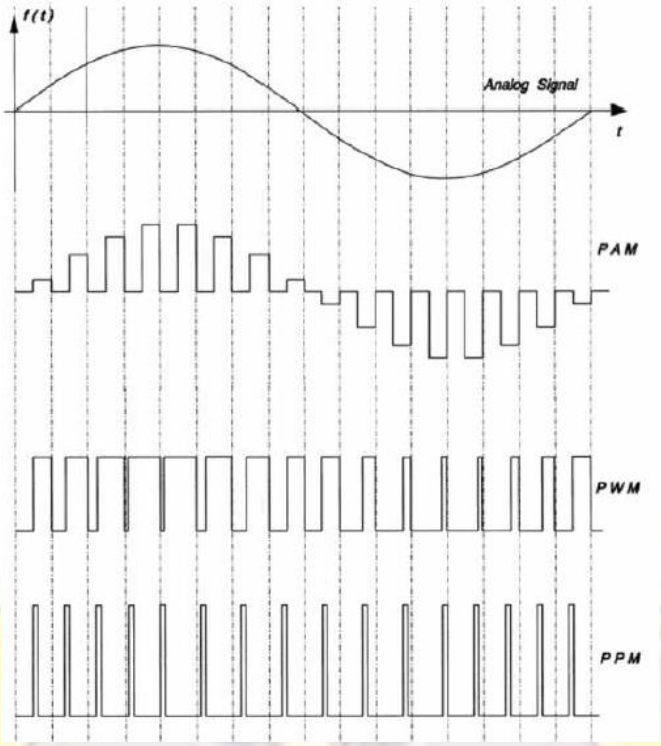
b) Delta Modulation

c) Differential Pulse Code Modulation (DPCM)

Pulse Amplitude Modulation (PAM)

– PAM is the simplest and most basic form of analog pulse modulation. In PAM the amplitude of regularly spaced pulses are varied in proportion to the corresponding sample values of a continuous message signal, the pulses can be of a rectangular form or other appropriate shape.

– PAM as defined here is somewhat similar to natural sampling where the message signal is multiplied by a periodic train of rectangular pulses. However, in natural sampling the top of each modulated rectangular pulse varies with the message signal, whereas in PAM it is maintained flat.



– In PWM, the signal f(t) is sampled periodically at a rate fast enough to satisfy the requirements of the sampling theorem. At each sampling instant a pulse is generated with fixed amplitude and a width that is proportional to the sample value of f(t). A minimum pulse width is assigned to the minimum value of f(t).
– In PPM, these are sent as constant width, constant amplitude pulses. The minimum pulse delay is used to designate the minimum value of f(t) and the change in delay is proportional to the modulating signal. The constant of proportionality is the modulation constant**.**

Example: For a pulse-amplitude modulated (PAM) transmission of voice signal having maximum frequency equal to fm = 3kHz, calculate the transmission bandwidth. It is given that the sampling frequency fs = 8 kHz and the pulse duration τ = 0.1Ts.

Example: For an input waveform of rectangular spectrum of bandwidth B (Hz), draw the natural sampled version of this input signal and calculate the PAM bandwidth (BW) if the sampling frequency is 4KHz and the duty cycle of the switching waveform is 0.33 of Ts.

Example: Proof that the bandwidth of any type of PAM is where τ is the duty cycle of the pulse.

There are three types of sampling techniques for transmitting a signal using PAM.

1. Ideal sampling PAM
2. Flat top sampling PAM
3. Natural sampling PAM

Ideal Sampling PAM

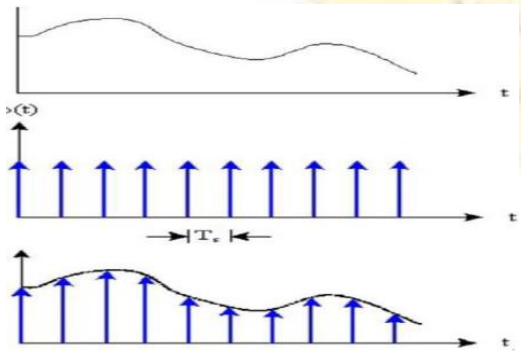
Ideal Sampling is also known as instantaneous sampling or Impulse Sampling. Train of impulse is used as a carrier signal for ideal sampling. In this sampling technique the sampling function is a train of impulses and the principle used is known as multiplication principle.

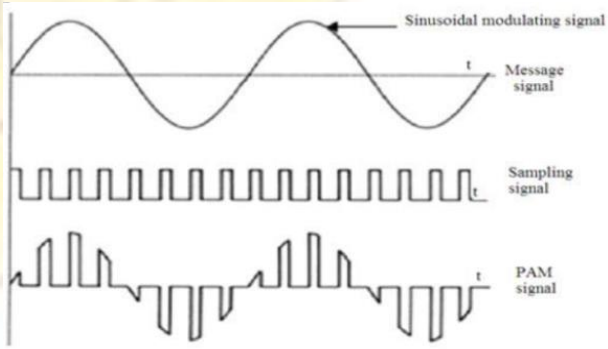
Flat Top Sampling PAM

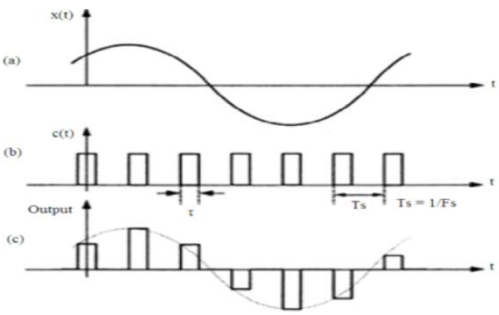
The amplitude of each pulse is directly proportional to modulating signal amplitude at the time of pulse occurrence. The amplitude of the signal cannot be changed with respect to the analog signal to be sampled. The tops of the amplitude remain flat.

Natural Sampling PAM

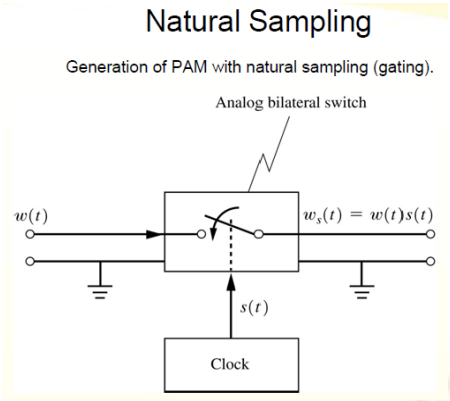
The amplitude of each pulse is directly proportional to modulating signal amplitude at the time of pulse occurrence. Then follows the amplitude of the pulse for the rest of the half-cycle.

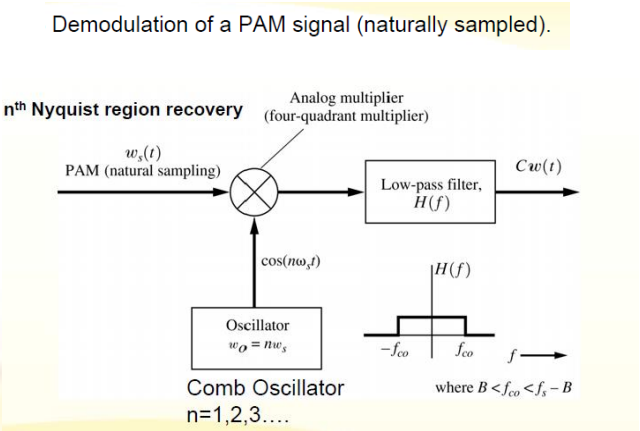




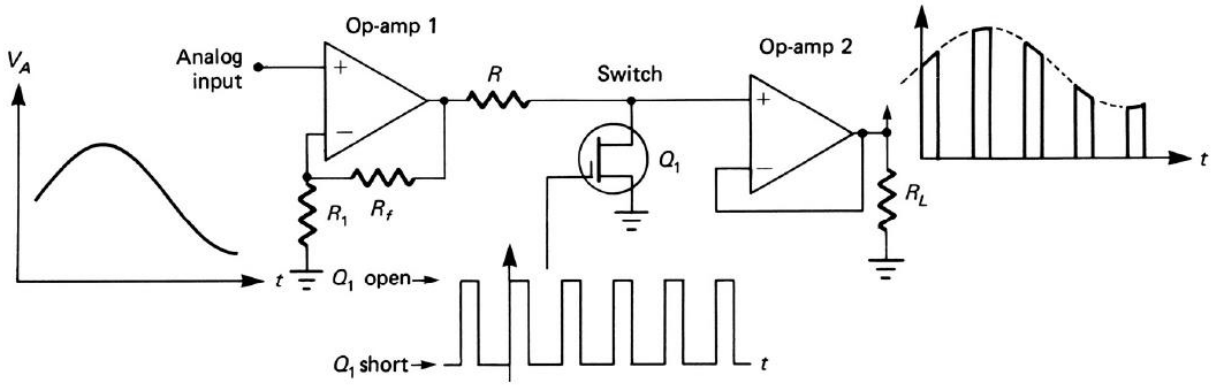


Modulation and demodulation of PAM

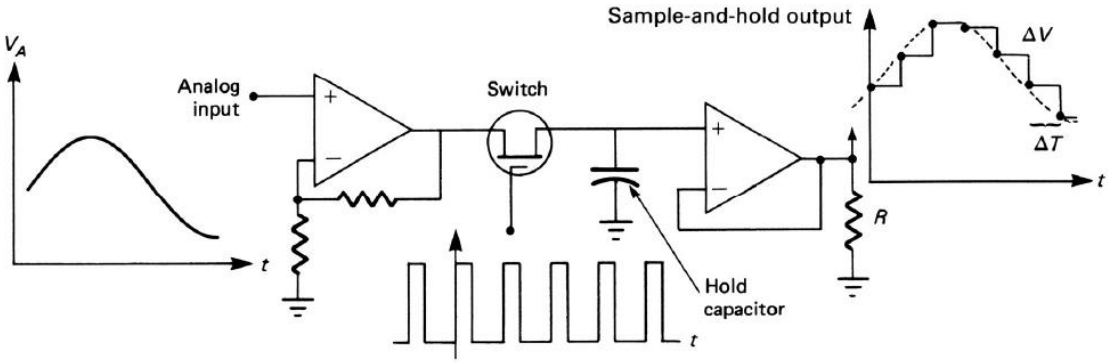




Pulse amplitude modulator, natural sampling.



Sample-and-hold circuit and flat-top sampling.



Applications of PAM

a) It is used in Ethernet communication.
b) It is used in many micro-controllers for generating control signals.
c) It is used as an electronic driver for LED lighting.
d) This modulation technique is mostly used in digital data transmission & applications changed by PCM &PPM.

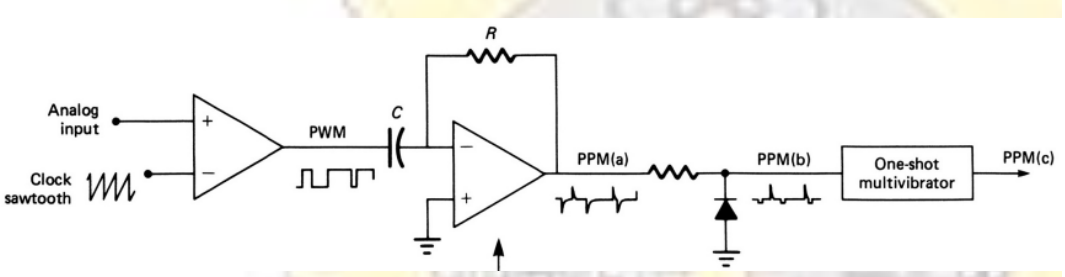
Advantage of PAM

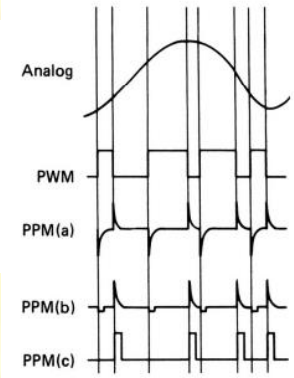
a) Simple modulation and demodulation.
b) Transmitter and receiver very simple and easy to construct .

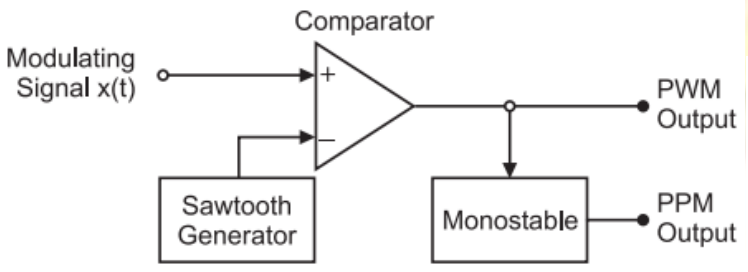
Disadvantage of PAM

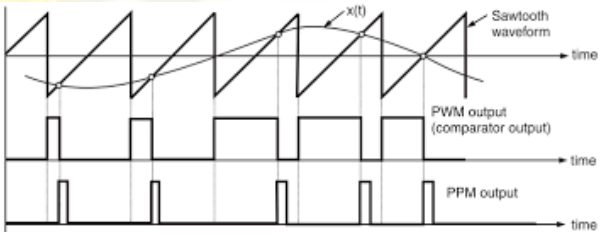
a) Wide bandwidth require $B_{PAM} \geq 1/2\tau$ τ *is width pulse.*
b) High noise interference.
c) Vary the peak power required for transmitter.

Pulse Width and Pulse Position Modulation

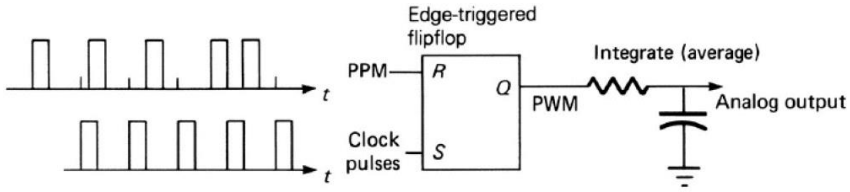


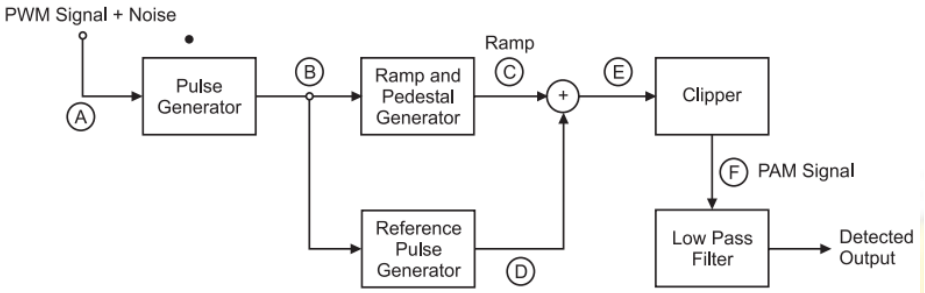


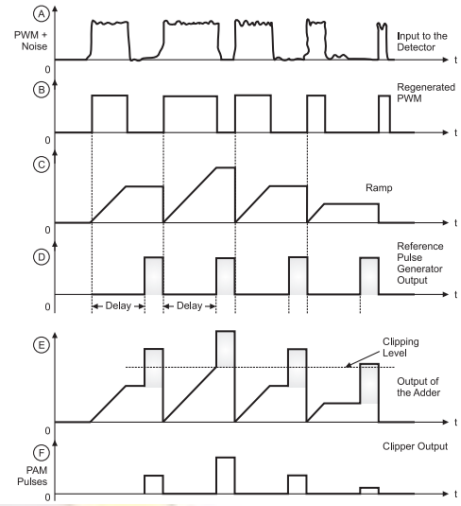




Demodulation







Example: Consider PAM transmission of voice signal with 3KHz bandwidth, calculate the total BW if the sampling frequency is 8 KHz and 0.1 Ts duty cycle.

Example: PAM waveform $g(t)=\sin\omega_m t$, when the message frequency is 5Hz and sampling frequency is 100Hz, calculate the total transmission BW if the duty cycle is 0.25 Ts.

Example: what is the transmission BW of a PAM signal g(t) = 2rect(t) with 150 Hz sampling frequency and the duty cycle is 10% of the sampling frequency.

Practical circuits of PAM